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(72) Inventors JOHN JAMES SWOBODA, JR and NORMAN LEE SWOBODA

(19) THE PATENT OFFICE LONDON

(54) RACKING ARM FOR COMPONENTS USED IN WELL DRILLING OPERATIONS

(71) We, JOHN JAMES SWOBODA, Jr. of 5602 Chippendale Street, Victoria, Texas, U.S.A., and NORMAN LEE SWOBODA, of 1309 East Commercial Street, Victoria, Victoria County, Texas, U.S.A., both citizens of the United States of America, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to well drilling operations, and more particularly relates to a device for assisting in the handling of vertical sections of pipes, drill collars, riser pipes and the like in a well drilling rig.

As is well known, it is necessary during the drilling of oil wells to transport elongated pipe members in a vertical position to and from various locations on the oil drilling rig. For example, additional sections of drill pipe must be periodically moved from a setback area to the well hole as the well is extended further into the ground, or when a drill bit needs replacement, the drill pipe sections must be removed and temporarily stored in the setback area. Moreover, during drilling operations, drill collars must be removed from a setback area and transported to the drilling area. In addition, when drilling is being done on an offshore platform, riser pipes having an irregular cross-sectional area must be moved to the blowout preventers from a racking area.

Generally, such elongated pipe members as pipe sections, drill collars or riser pipes are lifted in a generally vertical position by means of a traveling block on a derrick hoist. When such pipe members are being transported in a vertical position, the lower end of the pipe members tend to sway. Not only does such swaying movement of the pipe members tend to present a safety problem to the drilling rig and personnel, but such movement of the pipe members may make it difficult to guide the pipe members to the desired location which may comprise a relatively small opening. The problem of swaying of pipe members is particularly critical when the drilling is being performed from a floating offshore vessel which is subject to severe pitching and rolling due to high winds and waves.

Heretofore, it has been known to manually attempt to restrain such pipe members from swaying during transport. Man-handling the pipe has not been particularly successful due to the large mass and unpredictable movement of the pipe members, and in some instances the attempt to manually restrain the pipe members has presented safety problems to personnel. A number of mechanical systems have thus been heretofore developed in an attempt to restrain the swaying of vertical pipe and to guide the pipe to the desired location in an oil drilling rig. As an example, U.S. Patents No. 2,828,024, 2,829,783 and 3,467,262 disclose extendable pipe engaging members which may be operated to position a suspended pipe over a well borehole. However, such prior devices are limited to movement in a single horizontal plane and are provided only with extremely limited pivotal movement about a vertical axis, and are thus not practical for use in a well drilling environment to move a variety of different types and sizes of pipe members to a plurality of locations. In addition, such prior art devices have been subject to overload damage in case of sudden vertical or lateral movement of the pipe member. Previously developed systems have also not heretofore enabled the selective guiding of

riser pipes, due to the various irregular shapes and configurations of the riser pipes.

In accordance with the present invention, a racking arm is provided which substantially reduces or eliminates many of the problems heretofore experienced in prior systems. The invention provides a racking arm, when mounted on the working platform of a drilling rig for use in handling elongated members such as pipe sections, drill collars, riser pipe and the like used in rotary drilling of earth formations, said racking arm comprising:

a pedestal secured to said working platform away from said well bore axis,

a cantilevered telescoping boom supported by said pedestal at one end for pivotal movement about a vertical and a horizontal axis,

gripping means secured to the free end of said boom for engaging the exterior surface of said elongated members,

first power means connected between said pedestal and said boom for selectively rotating said boom about said vertical axis,

second power means connected between said pedestal and said boom for selectively rotating said boom about said horizontal axis for raising and lowering said free end, and

means in said boom for extending and retracting said boom to selectively vary the length thereof.

The present racking arm includes an extendable boom which may be selectively raised and lowered to dispose the gripping means in a variety of different horizontal planes. The arm may include a first gripper head which may loosely clamp about pipe sections or drill collars and a second gripper head which may be tightly clamped about riser pipe having an irregular cross-section. The gripper head may be automatically maintained at all times in a predetermined horizontal position regardless of the vertical position of the boom. The racking arm may include overload protection so that the boom is not damaged when the torque applied to the boom is exceeded by movement of the pipe member. The extendable boom may be arranged first to extend the larger and strongest boom sections and first to retract the smaller and weaker boom sections of its telescoping structure in order to maintain optimum stability of the boom in all states of extension and retraction.

The racking arm may be employed to grip and guide riser pipe having an irregular cross-section. In such a case, a gripper head may be mounted on the end of the boom which includes a cutout portion for receiving an inner peripheral portion of the riser pipe. A flexible chain is attached at one end to the gripper head and has a free end. The chain is of sufficient length to be wrapped around an outer peripheral portion of the riser pipe. Structure is provided to attach the free end of the chain to the gripper head so that the riser pipe is securely gripped for movement in a vertical position to the desired locations in the region of a well drilling platform.

When the racking arm is employed to guide elongated pipe members, a pipe gripper may be mounted on the free end of the boom which includes a gripper base having a semi-circular cutout portion for receiving a first peripheral portion of a vertical pipe. A movable gripper jaw is mounted on a side of the base and includes a curved portion for receiving a second peripheral portion of the pipe. At least two linear lengths pivotally interconnect the base and the jaw so that the jaw may be moved to and from the base in a generally linear path. A pressurized cylinder is connected between the base and the jaw for selectively moving the jaw to and from the base.

Preferred features of the invention will now be described with reference to the accompanying drawings, in which:

FIGURE 1 is a top view of a typical installation of the present racking arm on an offshore drilling platform;

FIGURE 2 is a side view of the present racking arm;

FIGURE 3 is a rear view of the racking arm shown in FIGURE 2;

FIGURE 4 is a top view of the pipe section gripper head in the closed position;

FIGURE 5 is a top view of the gripper head shown in FIGURE 4 in the opened position;

FIGURE 6 is a top view of the gripper head shown in FIGURE 4 with inserts added to enable gripping of smaller diameter pipes;

FIGURE 7 is a top view of the riser pipe gripper head of the invention with a riser pipe gripped in a first position;

FIGURE 8 is a top view of the riser pipe gripper head shown in FIGURE 7 with a riser pipe clamped in a second alternate position;

FIGURE 9 is a perspective view of the present racking arm in a partially extended position including the gripper head shown in FIGURE 4;

FIGURE 10 is a perspective view of the racking arm in a fully extended position including the gripper head shown in FIGURE 7;

FIGURE 11 is a sectional view, partially broken away, of the boom of the present invention;

FIGURE 12 is a sectional view taken generally along section lines 12—12 in FIGURE 11;

FIGURE 13 is a side view, partially sectioned, of the swivel assembly of the present racking arm; and

FIGURE 14 is a schematic drawing of the hydraulic control circuitry for operation of the boom.

Referring to FIGURE 1, a top view of a typical installation of the present invention is illustrated on an offshore drilling platform designated generally by the numeral 10. The platform includes a conventional rotary table 12 having a well bore 14, with a mousehole 16 and a rathole 18 located adjacent the table 12. A pair of drill pipe setback areas 20 and 22 are positioned opposite the rotary table 12, with a pair of drill collar setback areas 24 and 26 being positioned between the areas 20 and 22 and the table 12. The platform includes a deadman anchor 28, a derrick leg bedplate 30 and a stand pipe manifold 32.

The racking arm of the invention is illustrated generally by the numeral 34 and is positioned between the rotary table 12 and the derrick leg bedplate 30. The racking arm 34 includes an extendable boom 36 including an outer housing and three extendable boom sections 38, 40 and 42. A control console 44 includes five manually operable levers 46 to enable control and operation of the racking arm. The boom 36 includes a supported end 48 which is pivotal about a vertical axis 50. The vertical axis 50 is spaced away from bore hole 14 and is positioned to enable access by the boom 36 to the various setback areas on the platform, while also enabling access to the well bore 14, the mousehole 16 and the rathole 18.

A pipe gripper head 52 is mounted on the free cantilevered end of the boom 36 and includes a gripper base 54 having a cutout portion 56 for receiving a portion of the periphery of pipe section 58. The gripper head 52 also includes a movable gripper jaw 60 which is pivoted relative to the base 54 and is movable relative thereto by operation of a hydraulic cylinder 62. As will be subsequently described in greater detail, the gripper head assembly 52 clamps about a pipe section or a drill collar in order to guide the pipe members to the desired location, while allowing movement of the pipe members along their vertical axes. An alternate gripper head may be utilized with the boom to enable rigid gripping of riser pipe for transportation to the blowout preventers.

The boom 36 in the illustrated position is pivotal about the vertical axis 50 to scribe a minimum arm radius illustrated by the arc 64. When the boom is extended to the maximum extent by selective operation of the levers 46, the racking arm 34 may be operated about a maximum arm radius illustrated by the arc 66. It will thus be apparent that the racking arm 34 may be operated substantially over the entire area of the well bore and the setback areas of the platform.

FIGURES 2 and 3 illustrate side elevational views of the racking arm 34, and like numbers will be utilized in the various drawings for like and corresponding parts. The boom 36 comprises an outer housing 70 which receives the three telescoping boom sections 38, 40 and 42. The gripper head 52 is pivotally connected at pivot 72 to the lower end of the housing 42. A hydraulic cylinder 74 is mounted within the outer end of the housing 42 and includes an extendable rod 76 which is pivotally connected at pivot 78 to the upper portion of the gripper head 52. As will be later described, cylinder 74 is operated by the hydraulic control circuit to maintain the gripper head 52 in a selected position (usually horizontal) regardless of the attitude of the boom 36. In this manner, pipe members may be grasped at high or low positions without causing binding of the pipe members within the gripper head 52.

The boom 36 is mounted at the supported end upon a pedestal 80 which includes a base 82 which may be rigidly bolted to the floor of the well drilling platform. The opposite end of boom 36 comprises a free cantilevered end which may be selectively moved in any direction. A hydraulic power unit assembly, not shown, is connected to the pedestal 80 in order to supply pressurized fluid thereto. The upper portion of the pedestal 80 supports a gear 84, best shown in FIGURE 3, which meshes with a gear 86 driven through a gear box 88 by a hydraulic drive motor 90. The gear box 88 and motor 90 are mounted on a platform 92 supported by two spaced apart flanges 94 and 96 connected to a side brace 98. A second side brace 100 is spaced apart from brace 98 and both braces 98 and 100 are connected to a pivot platform above gears 84 and 86. Operation of motor 90 causes rotation of gear 86 to thereby pivot the upper assembly relative to the fixed pedestal 80.

As best shown in FIGURE 3, a ten-way hydraulic swivel assembly 102 is mounted between the side braces 98 and 100 and serves to communicate hydraulic pressure applied from the pedestal 80 to the various hydraulic motors and cylinders of the racker arm. For example, pressrized hydraulic fluid is applied through hydraulic cables 104 and 106 from the swivel assembly 102 to the boom 36 in order to operate the hydraulic cylinders which control the extension and retraction of the boom. This pressurized fluid also controls the operation of the hydraulic cylinder 74 in order to control the attitude of the gripper head 52. A more

detailed description of the ten-way hydraulic swivel assembly 102 will be described with respect to FIGURE 13.

As shown in FIGURE 2, a hydraulic cylinder 110 is pivotally connected at a pivot 111 to the pivot platform located above the pedestal 80. The cylinder rod 112 of the cylinder 110 is pivotally connected at 114 to the underside of the boom housing 70. Housing 70 is pivotally supported between the side braces 98 and 100 by a pivot pin 118. Cylinder 110 is slaved with cylinder 74 in order to maintain the gripping head 52 in a selected position. Cylinder 110 senses the attitude of the boom 36 and varies the volume of oil in cylinder 74 in order to maintain the gripper head 52 level at all times.

A cylinder 120 is pivotally mounted at pivot 122 in base member 124. The rod 126 of the cylinder 120 extends upwardly to a pivotal connection 128 with the underside of the boom housing 70. Hydraulic fluid for operation of the cylinder 120 is applied from the swivel assembly 102 via hydraulic lines. A counter balance shut off valve 130 is provided on the lower portion of cylinder 120 to provide a counter balance to the system by sealing the cylinder 120 in case of failure of one of the hydraulic lines. Cylinder 120 is utilized to raise and lower the boom 36 in a manner to be described in detail with respect to the hydraulic circuitry shown in FIGURE 14.

The console 44 includes five levers 46 as previously noted to enable operator control of the system. While the illustrated embodiment shows a hydraulic valve control system, it will be understood that an electrical control system could alternatively be utilized. In the preferred embodiment, the first lever moves the boom up and down, the second lever moves the boom in and out, the third lever pivots the boom left or right, the fourth lever opens and closes the gripper head and the fifth lever moves the gripper head up or down as desired. Each of the levers 46 comprises a conventional hydraulic control lever system which controls the application of pressurized fluid to the various cylinders and motors of the system shown in FIGURES 2 and 3.

FIGURES 4—6 illustrate in greater detail the construction and operation of the pipe section and drill collar gripper head assembly 52. As previously noted, the gripper head 52 comprises an integral unit which may be selectively pinned or unpinned to the cantilevered free end of the boom 36. In this manner, different types of gripper heads may be easily connected to the system for use with different applications.

Referring to FIGURE 4, the assembly comprises the gripper base 54 including a rear portion 140 having a generally triangular cross-section as shown in FIGURE 2. At the rear of the rear portion 140, a pair of lugs 142 and 144 are provided to enable pinning of the assembly to the end of housing 42 at the pivot point 72 (FIGURE 2). At the top center of the rear portion 140 is a lug 146 to enable pinning of the assembly to the rod 76 at the pivot point 78 as shown in FIGURE 2. Quick disconnect couplings 148 and 150 enable disconnection of the hydraulic lines of the assembly. The quick disconnect coupling 148 connects with hydraulic lines 152 and 154 and to the lower portion of the cylinder 62, while the quick disconnect coupling 150 connects with the hydraulic lines 156 and 158 and to the upper portion of the hydraulic cylinder 62. As previously noted, hydraulic pressure is applied to lines 154 and 158 via the ten-way hydraulic swivel assembly 102 shown in FIGURE 3.

The rod 160 of cylinder 62 is pivotally connected at 162 to the gripper jaw 60. The gripper jaw 60 includes a curved cutout portion 164 for clamping about a portion of the periphery of a vertically extending pipe section or drill collar. The jaw 60 is pivotally connected to a rigid linkage 166 and is pivotally connected at a spaced apart pivot point 168 to a second rigid linkage 170. Linkage 166 is shorter than linkage 170. Linkage 166 is connected at pivot 172 to the gripper base 54 and linkage 170 is connected at pivot 174 to the base 54. A lifting eye 176 is connected to the base 54 to assist in manual installation of the gripper head. As previously noted, the base 54 includes a semi-circular cutout portion 56 for clamping against one-half of the periphery of a pipe section or drill collar.

FIGURE 5 illustrates an important aspect of the gripper head 52 in that the gripper jaw 60 moves away from the gripper base 54 in a generally linear manner. This enables the gripper head 52 to clamp about a pipe section with much less required space than if the cutout sections 56 and 164 were directly hinged together. The present gripper assembly may thus be used to clamp and unclamp pipe sections or drill collars in a minimum space. The generally linear action is provided by the fact that the short linkage 166 tends to move the jaw inwardly, while the linkage 170 moves the jaw 60 outwardly away from contact with the base 54. The cylinder 62 is operated to retract the rod 160 in order to open the gripper jaw as illustrated in FIGURE 5.

FIGURE 6 illustrates the connection of clamp inserts 180 and 182 to the gripper head in order to enable the assembly to clamp pipe sections or drill collars of smaller diameters. The insert 180 includes a base 184 with a pair of spaced apart aper-

tures 186. Retainer pins 188 rigidly connected to the base 54 extend through the apertures in order to securely fasten the insert to the base 54. Insert 182 includes an aperture 190 which receives a retainer pin 192 in order to affix insert 182 to the jaw 60. It will be understood that a variety of different sizes of insert sets may be utilized to enable the present device to guide a wide range of pipe member sizes.

An important aspect of the present racking arm is the ability to clamp riser pipe having an irregular cross-section. The riser pipe gripper head 200 is illustrated in FIGURES 7 and 8 and includes a rigid base 202 having a pair of spaced apart lugs 204 and 206 operable to be pivotally pinned to the free cantilevered end of the boom 36 in the same manner as the gripper head 52. A central lug 208 is also adapted to be pivotally pinned to the rod 76 of the cylinder 74 as previously described. Operation of the rod 76 enables pivotal movement of the gripper assembly 200 about the lugs 204 and 206 in order to vary the attitude of the gripper assembly. The base 202 includes a pair of semi-circular cutout portions 210 and 212. Riser pipe may be gripped in either of the cutout portions 210 or 212, depending upon the position of the riser pipe when clamped and depending upon the desired arc of movement of the riser pipe.

Figure 7 illustrates a riser pipe assembly 214 clamped in the cutout portion 210. Riser pipe assembly 214 includes a plurality of pipes 216 which provide the riser pipe assembly with an irregular cross-section. In use of the present gripper assembly, the riser pipe is positioned within the cutout portion 210 and a chain 218 is wrapped around the outer periphery of the riser pipe in order to rigidly clamp the riser pipe within the gripper head assembly 200. Chain 218 may be replaced by any other suitable flexible linkage such as a cable or the like. Chain 218 is connected to an end of a cylinder rod 220 and passes around a roller 219. Operation of the cylinder 222 causes the chain 218 to be tightened about the riser pipe. Cylinder 222 is connected by a pivot 224 to the base 202. The free end of the chain 218 is hooked about a hook 228 after being wrapped around a riser pipe. In operation, the riser pipe assembly 214 is positioned within the cutout portion 210. The free end of the chain 218 is then wrapped around the riser pipe assembly and is hooked on the hook 228. The cylinder 22 is then energized in order to tighten the chain 218 around the riser pipe assembly to securely clamp the riser pipe to the gripper head 200.

FIGURE 8 illustrates the use of the present gripping head to grip the riser pipe assembly 214 in the cutout portion 212. In this mode of operation of the gripping head 200, the chain 218 is passed around the roller 219 and around the outer periphery of the riser pipe assembly 214 and is hooked upon a hook 230 extending from the base 202. The cylinder 222 is energized in order to tighten the chain 218 about the riser pipe assembly 214. The irregular cross-sectional shape of the riser pipe assembly may be accommodated due to the flexible nature of the chain or cable 218.

FIGURES 9 and 10 are perspective views of the racking arm 34 and illustrate the operation of the extendable boom 36. Like numbers are utilized for like and corresponding parts in this drawing previously described. As previously mentioned, operation of the hydraulic motor 90 operates through the gear train 88 to rotate the upper housing relative to the pedestal 80. In this manner, the extendable boom 36 may be rotated any amount about a vertical axis. Further, upon energization of the hydraulic cylinder 120, the boom housing 70 and consequently the entire extendable boom may be selectively moved up and down to enable the pipe member to be gripped at any desired height. By operation of the cylinder 74, the cylinder rod 76 may move the gripper head 52 up or down. Normally during operation, the gripper head 52 will be automatically maintained in a horizontal position by operation of the hydraulic control system which will be subsequently described. Operation of the cylinder 62 enables the gripper jaw 60 to open and close against the gripper base 54 as previously described.

Each of the telescoping boom sections 38, 40 and 42 include a corresponding hydraulic cylinder which enables selective individual operation of each boom section. For example, section 38 includes a cylinder rod 240 which may be selectively extended or retracted in order to move the section 38 into and out from the housing 70. Similarly, sections 40 and 42 include separate hydraulic cylinders which enables relative movement of the sections to one another. As shown in FIGURES 9 and 10, the housing 70 has the largest cross-sectional area and receives each of the sections 38, 40 and 42 in a telescoping manner. Similarly, section 38 has a larger cross-sectional area than do the innermost sections 40 and 42. Likewise, section 40 has a larger cross-sectional area than the innermost section 42.

An important aspect of the present invention is that the outermost sections are first extended prior to any extension of the innermost sections. Similarly, during retraction, the innermost sections are first retracted prior to any retraction of the outermost sections. Thus, the boom is provided with the optimum stability and strength at any point of extension or

retraction. For example, FIGURE 9 illustrates a mid-point in the extension of the boom 36. In this position, section 38 is fully extended from the housing 70 and section 40 is just beginning to be outwardly extended from section 38. Section 42 is not extended whatsoever from section 40. In operation, section 40 will be fully extended from section 38 before any extension is provided to the innermost section 42.

FIGURE 10 illustrates the boom 36 in a fully extended position utilizing the gripper head 200 for riser pipe clamping. To retract the boom, the innermost section 42 is first retracted within the section 40. Thereafter, section 40 and section 42 are retracted within the outermost section 38, and then section 38 is retracted within the housing 70. In this manner, the larger and therefore stronger outermost sections are utilized to bear the load when at all possible. This construction and operation differs from prior extendable booms utilizing cables wherein all sections are extended and retracted simultaneously.

FIGURE 11 is a sectional view, partially broken away, of the boom 36 illustrating the interconnection of the sections 38, 40 and 42 of the housing 70. A first hydraulic cylinder 242 is rigidly connected to the top of the housing 70 and includes the cylinder rod 240 which is pivotally connected at 244 to a lug 246 attached to the top of the section 38. Section 38 includes a second hydraulic cylinder 248 having a rod 249 connected by a clevis pin 250 to the rear wall of section 38. Clevis pin 250 is mounted on a spacer 251 mounted across the back of section 38. A bracket 252 is connected to the top rear of the section 38 and includes a roller 254 which rolls against the underside of the housing 70.

Cylinder 248 is rigidly interconnected with a third cylinder 258 which is rigidly connected by a pin 260 to a bracket rigidly connected to the rear of the section 40. A roller 262 is connected to the lower rear of the section 38 to roll against the bottom of housing 70, and a roller 264 is connected to the rear of section 40 in order to roll along the bottom of section 38. A roller 265 is attached to section 40 for rolling along section 38.

A cylinder rod 266 extends from cylinder 258 and is connected by a clevis pin 268 with a bracket 270 rigidly mounted within the innermost section 42. Section 42 includes rollers 272 and 274 mounted on a rear thereof to roll within section 40. Housing 70 includes, at the lower front end thereof, a support roller 280. Support rollers 282 and 284 are respectively mounted on the front portions of sections 38 and 40.

Operation of the extendable boom 36 will be apparent in FIGURE 11. When the boom is in the retracted position, hydraulic fluid is first applied to cylinder 242 and rod 240 causes the section 38 to be fully extended. Pressure is then applied to cylinder 248 and the rod 249 causes the section 40 to be fully extended from section 38. Pressurized fluid is then applied to cylinder 258 which causes the rod 266 to fully extend the innermost section 42. Upon retraction, the operation is reversed with the innermost section 42 being first retracted within section 40 as previously noted. The roller pins provided by the present invention provide smooth operation of the telescoping action of the boom at all times.

FIGURE 12 is a sectional view of the boom 36 taken along section lines 12—12. FIGURE 12 illustrates that cylinder 242 and cylinder rod 240 are mounted in the interior top of housing 70. As may be seen, guide rollers are connected between the housing 70 and the section 38 in order to provide smooth trouble-free operation of the boom. As shown in FIGURE 12, cylinders 248 and 258 extend through the middle of the innermost section 42 and serve to operate both sections 40 and 42 as previously described.

FIGURE 13 illustrates the ten-way hydraulic swivel assembly 102 previously shown in FIGURE 3. The swivel assembly 102 includes a central housing 290 which is fixedly attached to the top of the pedestal 80 (FIGURE 3). The assembly 102 further includes an outer housing 292 which is attached to the pivotal base above the pedestal 80 which rotates relative to the pedestal 80. Ten circular ports 300 are formed in the bottom of the housing 290 and extend upwardly through the length thereof. Each of the ports communicates with one of ten circular grooves 302 extending about the periphery of the housing 290. For example, port 304 communicates with the bottom of the housing 290 and extends upwardly into contact with the second circular groove around the top of the housing 290.

Ten ports 306 are formed through the walls of the outer housing 292. Each of the ports 306 communicates with a different one of the grooves 302. Hoses are attached to the ports 306 and are directed to the extendable boom 36 and to the various cylinders and motors of the system. Housing 290 remains stationary, while outer housing 292 rotates during pivoting of the boom 36.

FIGURE 14 is a diagram of the hydraulic control system for the racking arm. This system controls the operation of the cylinder 62 which opens and closes the gripper assembly, controls cylinders 74 and 110 which maintain the gripper assembly in a horizontal position, controls the cylinder 120 which raises and lowers the free cantilevered end of the boom, and controls

cylinders 242, 248 and 258 which controls the extension and retraction of the boom. The power unit 310 of the hydraulic system includes a hydraulic pump 312 which is operated by a 60-H.P. electrical motor 314. Motor 314 also operates a second hydraulic pump 316. Pressurized fluid is applied from pump 312 via pump lies 318 and 320. Relief valves 322 and 324 relieve the pump lines at 1200 psi and 1600 psi, respectively. Pump line 318 is directed to a four-way control valve 328 which controls the swing of the boom about the vertical axis. Line 330 connects the valve 328 with the hydraulic motor 90 which operates the gears 84 and 86 in the manner shown in FIGURE 3 in order to pivot the boom. A dual relief valve 332 is connected across the motor 90 in order to provide relief protection to the motor at 1000 psi.

The output of the motor 90 is applied through line 334 to valve 328. Line 336 is directed from the valve 328 to a four-way control valve 338 which operates to control the desired angular orientation of the gripper assembly. When the valve 338 is in the illustrated position, pressurized fluid is provided through line 340 to a four-way control valve 342 which operates to open or close the gripper jaw of the gripper assembly. The valve 342 thus controls the flow of pressurized fluid to the cylinder 62 connected on the gripper head shown in FIGURES 4 and 5. A low pressure relief valve 334 is connected to the input line to the 342 valve to relieve the valve at 600 psi. One output of valve 338 is applied through line 346 and through a needle valve 348 to a piloted control valve 350, termed the boom float valve. Line 346 is also applied to a dual relief valve 352 which provides crossover pressure relief at 1000 psi. The output of valve 352 is applied to a counter balance valve 354 and to a reservoir 356 and is also applied via line 358 to cylinder 75. Cylinder 74 is slaved with cylinder 110.

The second output from valve 338 is applied via line 360 and through a needle valve 362 to the boom float control valve 350. Line 360 is also connected through the dual relief valve 352 and via line 336 to the cylinder 110 (FIGURE 2). An output line 368 from the valve 352 is applied to a 200 psi relief valve 370.

The output line 320 from the pump 312 is applied to the boom lift four-way control valve 374. In the illustrated position, the valve 374 applies the fluid via line 376 to the boom float control valve 350. An 800 psi relief valve 378 is connected to line 376. The output of the control valve 374 is applied via lines 380 both to the boom float control valve 350 and to the boom lift cylinder 120. A counterbalance valve 382 set at 2500 psi is connected in series with lines 380.

The output from pump 316 is applied to an overcenter valve 388 and through a check valve 390 to line 392. A high-pressure relief valve 394 is set at 2000 psi and is connected to line 392. Line 392 is directed to a boom extension four-way control valve 396. Valve 396 controls the flow of fluid through line 398 through a counterbalance 400 to the cylinders 242, 248 and 258 connected in series, as illustrated. The output of cylinders 242, 248 and 258 is applied through line 402 and through a 2500 psi counterbalance valve 404 to the boom extension control valve 396. A pilot line 408 interconnects line 398 with the overcenter valve 388.

The power unit 310 will generally be mounted in a separate unit, not shown in FIGURES 1—13, which is conventionally connected to pedestal 80 to supply pressurized fluid thereto. The hydraulic circuitry located within the dotted line 412 is located within the controls console 44 shown in FIGURE 3. The remainder of the motors and cylinders are located on the boom as previously described.

In operation of the hydraulic circuitry shown in FIGURE 14, selected ones of the manual control levers 46 shown in FIGURE 3 will be operated in order to manually control the position of the control valves 328, 342, 338, 374 and 396. When it is desired to pivot the boom about the vertical axis, control valve 328 is operated in order to cause operation of the hydraulic motor 90. The motor 90 rotates gear 86 which operates against gear 84 in order to pivot the boom relative to the fixed pedestal 80 as previously described.

When it is desired to open or close the gripper head, valve 342 is operated in order to selectively move the gripper clamp cylinder 62 as shown in FIGURES 4 and 5. In the case of the gripper head shown in FIGURES 7 and 8, operation of the valve 342 controls the operation of the cylinder 222 in order to tighten or loosen the flexible chain 218.

As previously noted, cylinder 74 and 110 interact to maintain the gripper assembly in a desired position throughout all vertical movement of the free cantilevered end of the boom 36. Cylinders 74 and 110 are thus slaved, so that the volume of hydraulic fluid in cylinder 110 is changed when the boom is moved up or down. The change of hydraulic fluid in cylinder 110 thus causes a corresponding opposite change in the volume of hydraulic fluid in cylinder 74, in order to change the angle of the gripper head with respect to the boom in order to maintain the desired preset angle of the gripper head. The preset angle of the gripper head is adjusted by operation of control valve 338.

The relief valve 370 maintains a minimum of 200 psi in the lines on the low pressure side of the cylinders. Valve 370 thus insures that air is kept out of the system due to the maintenance of 200 psi and thus compensates for the difference in area between cylinders 74 and 110. The counterbalance valve 354 is important in providing overload release in case the boom is overloaded faster than cylinder 110 can compensate for. Upon overload fluid is dumped into reservoir 356.

An important aspect of the invention is that the boom 36 automatically floats vertically up and down with the riser pipe when the riser gripper head is engaged with the riser pipe. This floating action is provided by the boom float control valve 350. Thus, the boom 36 may float with vertical movements of the riser pipe during movement from one location to another without harm to the boom. This floating operation is not required when the pipe section or drill collar gripping head is being utilized, as the pipe section or drill collar are not tightly gripped, but are allowed to move vertically with respect to the gripping head. Thus, when pipe sections or drill collars are gripped, the pipe sections or drill collars are able to move vertically along their axes and the gripper head is maintained in a predetermined angle to prevent binding up.

To explain the floating boom action, assume an upward force is exerted on boom 36. As the pressure begins to build up due to lifting on the cylinder 74, the hydraulic fluid supplied through line 346 is applied to the boom float control valve 350 and the cylinder 120 is allowed to raise the boom 36 to compensate for the overload in pressure. If an excessive downward load is applied to the boom, the cylinder 74 picks up the load and pressurized fluid is applied through line 366 to the boom float valve 350 and the cylinder 120 pulls the boom downwardly in order to automatically compensate for the overload.

When it is desired to lift or lower the cantilevered free end of the boom 36 to initially clamp onto a pipe member, the valve 374 is actuated by the respective manual lever and pressurized fluid is applied to the boom lift cylinder 120 in order to selectively raise or lower the boom about the pivot point 118 as previously described. Lifting of the boom 36 will cause pressurized fluid to be transferred from cylinder 110 to cylinder 74 in order to maintain the desired position of the gripper head relative to the horizontal.

When it is desired to extend or retract the boom 36, the boom extension valve 396 is selectively operated and pressurized fluid is applied from the pump 316 to the cylinders 242, 248 and 258. Due to the serial connection of the cylinders, the outermost sections are initially extended prior to the extension of the innermost section, as previously noted, in order to maintain the maximum strength of the boom at all times.

While the present invention has been primarily disclosed with respect to a manual control console, it should be understood that automatic or preprogrammed controls could be provided to the present racking arm. As an example, a limit switch system could be provided so that the boom automatically swings to and from the well bore, rathole or mousehole and predetermined setback areas. Alternatively, a properly programmed digital computer could be utilized in order to operate the boom according to preprogrammed instructions.

WHAT WE CLAIM IS:—

1. A racking arm, when mounted on the working platform of a drilling rig for use in handling elongated members such as pipe sections, drill collars, riser pipe and the like used in rotary drilling of earth formations, said racking arm comprising:

a pedestal secured to said working platform away from said well bore axis,

a cantilevered telescoping boom supported by said pedestal at one end for pivotal movement about a vertical and a horizontal axis,

gripping means secured to the free end of said boom for engaging the exterior surface of said elongated members,

first power means connected between said pedestal and said boom for selectively rotating said boom about said vertical axis.

second power means connected between said pedestal and said boom for selectively rotating said boom about said horizontal axis for raising and lowering said free end, and

means in said boom for extending and retracting said boom to selectively vary the length thereof.

2. A racking arm according to claim 1 and further comprising:

an automatic parallel arm interposed between said free end of said boom and said gripping means, said parallel arm being operable to maintain said gripping means in a constant attitude relative to the horizontal during vertical movements of said boom.

3. A racking arm according to claim 1 or 2 wherein said gripping means is adapted to grip pipe for imparting lateral movement thereto while permitting such pipe to slide vertically on its own axis, and wherein said boom is allowed to pivot about said horizontal axis if said pipe becomes stuck in said gripping means so that said pipe cannot so slide axially.

4. A racking arm according to claim 1, 2, or 3 wherein said gripping means is con-

structured to grip riser pipe having a generally irregular cross-sectional shape.

5. A racking arm according to any of claims 1 to 4 and further comprising:

means operatively associated with said second power means for allowing floating movement of said boom when a force is applied to said boom through said elongated member being gripped.

6. A racking arm according to any of claims 1 to 5 wherein said second power means comprises:

a first hydraulic cylinder mounted between said pedestal and said boom for raising and lowering said boom,

a second hydraulic cylinder mounted to sense the vertical load applied to the free end of said boom, and

control valve means operable in response to said second cylinder to cause said first cylinder to move said boom up or down upon the occurrence of a predetermined load.

7. A racking arm according to claim 1 and further comprising:

means attached between said gripping means and said boom for moving said gripping meas vertically relative to said boom.

8. A racking arm according to claim 7 and further comprising:

means for sensing the vertical position of the free end of said boom, said means for sensing being slaved to said means for moving said gripping means vertically.

9. A racking arm according to any of claims 1 to 8 and further comprising:

a supply of pressurized fluid connected to a plurality of supply lines in said pedestal,

a swivel assembly having an inner housing rigidly connected to said pedestal and an outer housing pivotally movable with said boom,

conduits formed through said inner housing and communicating with said supply lines, and

ports in said outer housing communicating with said conduits, and

fluid lines connected to said ports for supplying pressurized fluid to said first and second power means and to said means for extending and retracting.

10. A racking arm according to any of claims 1 to 9 and further comprising:

relief protection means operatively associated with said second power means for allowing said boom to pivot upon the occurrence of a predetermined overload condition.

11. A racking arm according to any of claims 1 to 10 wherein said first power means comprises:

a motor mounted for movement with said boom,

first gear means carried by said motor,

second gear means carried by said pedestal, said first and second gear means meshing to provide rotation of said boom relative to said pedestal.

12. A racking arm, when mounted on the working platform of a drilling rig for use in handling elongated pipe members used in rotary drilling of wells, said racking arm comprising:

a pedestal secured to said working platform of said drilling rig away from said well bore axis,

a swivel platform pivotally mounted above said pedestal,

means for pivoting said swivel platform about a vertical axis relative to said pedestal,

a cantilevered telescoping boom connected to said swivel platform for pivotal movement about a horizontal axis, said boom having an outwardly extending free end,

a first hydraulic cylinder connected at the lower end to said swivel platform and at the upper end to a location on said boom between said pivot axis and said free end,

a second hydraulic cylinder connected at the lower end to said swivel platform and at the upper end to a point on said boom on the opposite side of pivot axis from the point of connection of said first hydraulic cylinder with said boom,

a gripper assembly pivotally connected on said free end of said boom, and

a third hydraulic cylinder connected between said free end and said gripper assembly, said second and third cylinders being slaved together wherein said gripper assembly may be maintained at a desired constant attitude.

13. A racking arm, when mounted on a drilling rig, substantially as herein described with reference to the accompanying drawings.

For the Applicants,
CARPMAELS & RANSFORD,
Chartered Patent Agents,
43 Bloomsbury Square,
London, WC1A 2RA.

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1469661 COMPLETE SPECIFICATION

7 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

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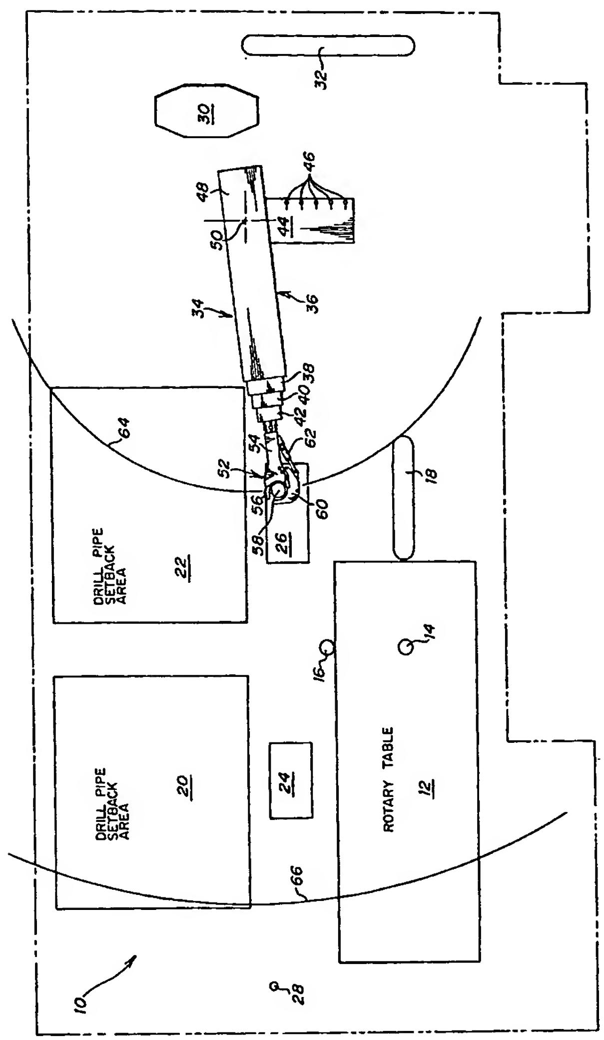

FIG. 1

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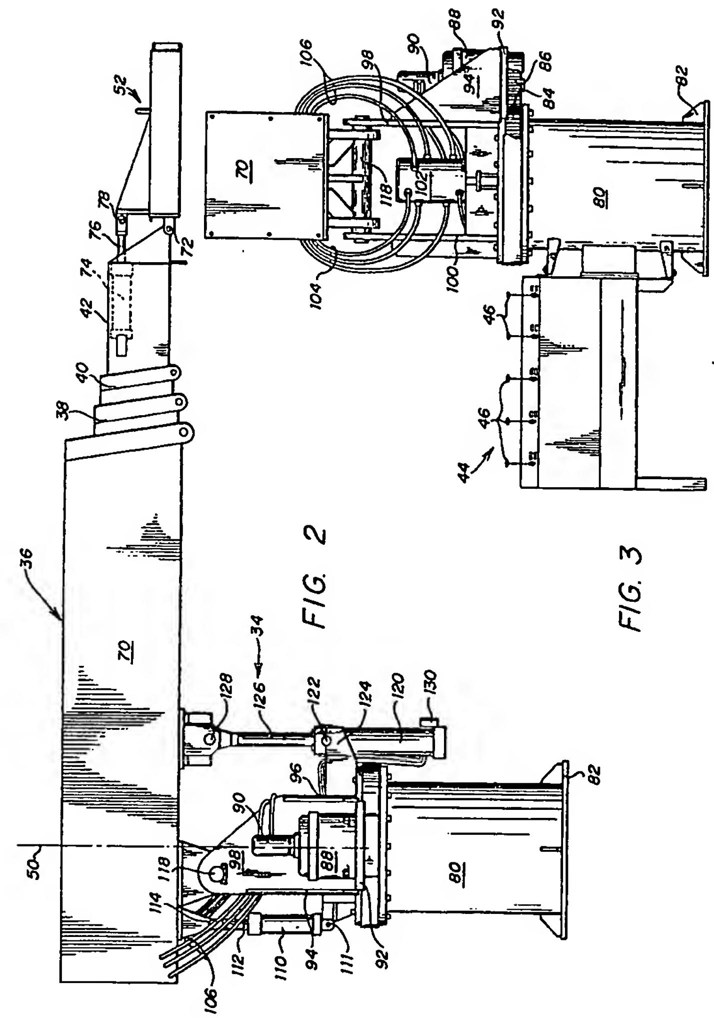

FIG. 2

FIG. 3

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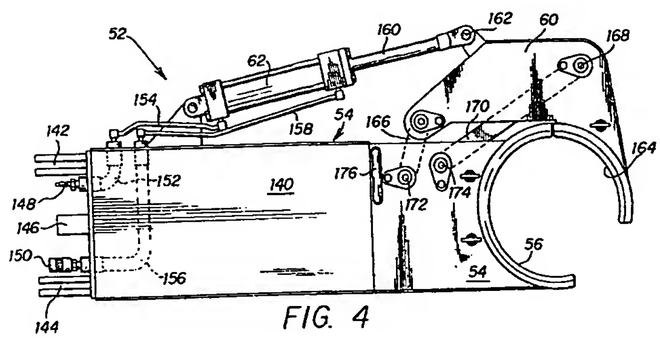
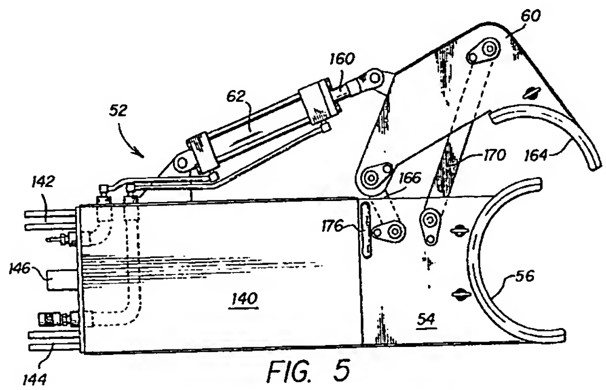


FIG. 4



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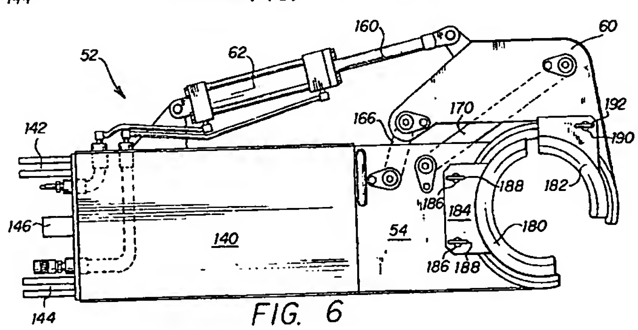

FIG. 6

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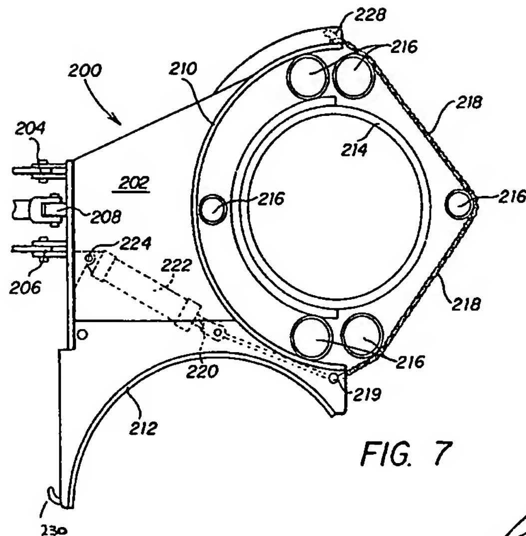

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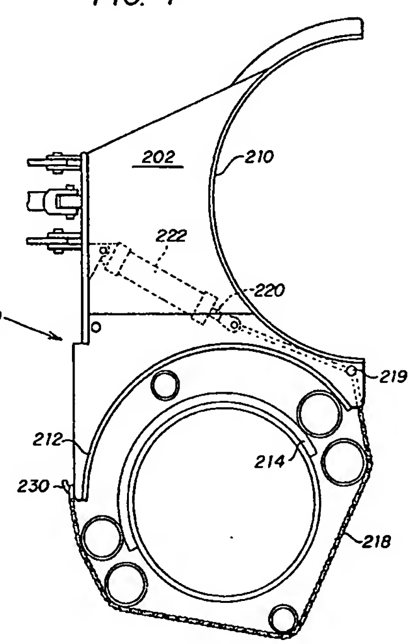

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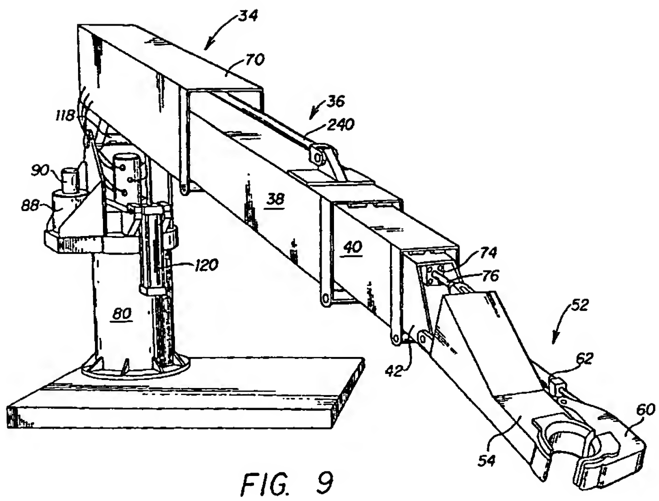
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FIG. 9

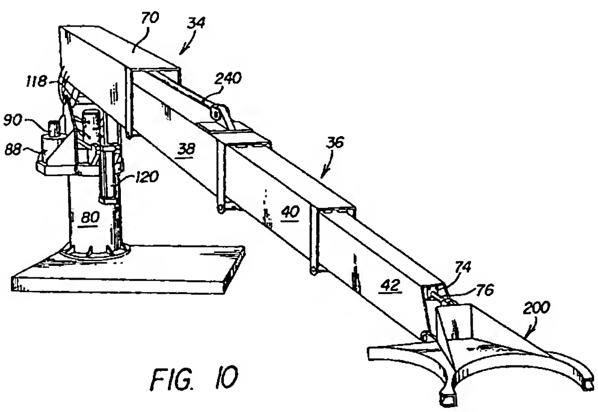
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FIG. 10

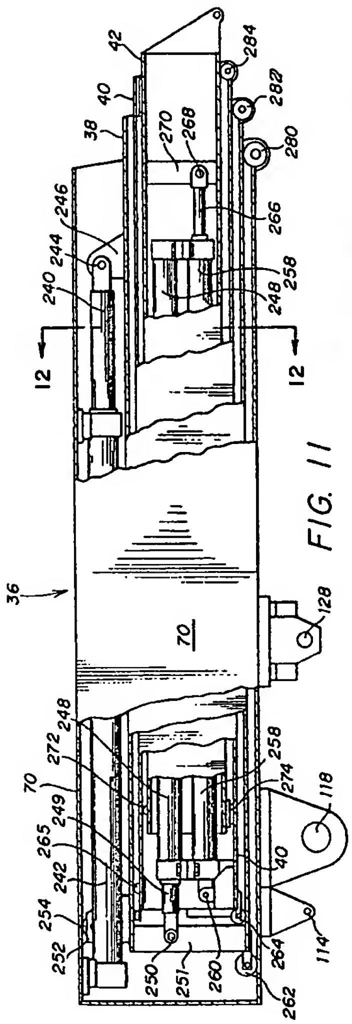

FIG. 11

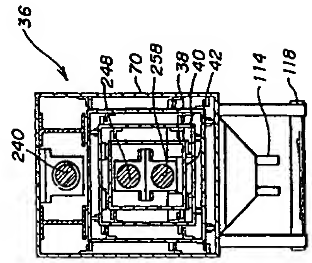

FIG. 12

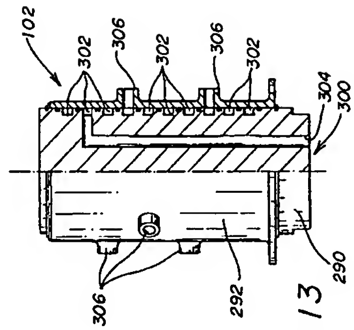

FIG. 13

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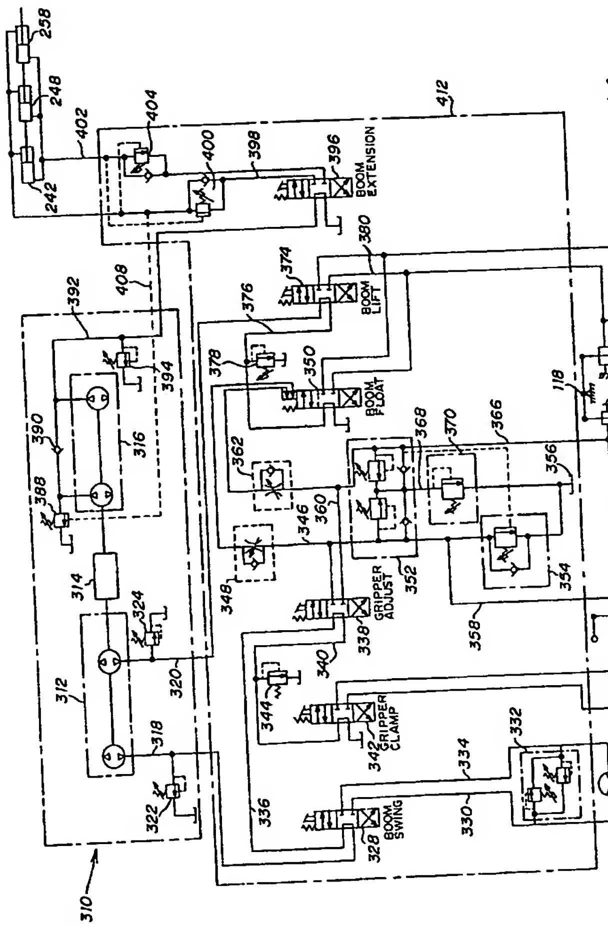

FIG. 14